

Application of Phase Change Wallboard to an Energy-Conservation Building in the Cold Area in North China¹

Guohui Feng
Ph.D.

Dan Deng
Master

Gang Li
Master

Shenyang Jianzhu University
Shenyang, China
Hj_fgh@sjzu.edu.cn

Abstract: The application of phase change energy storage has become an academic focus in building energy conservation. This paper considers day and night climate conditions and the governmental regulation of price of electricity in testing and analyzing the characteristics of phase change energy storage material with DSC. We selected two kinds of fatty acid as phase change material to make a phase change wallboard, and then carried out a thermal functional analysis of performance of the wallboard. The results indicate that the application of phase change wallboard in the cold northern region, where there are abundant natural resources, combined with the national policy of reducing the cost of electricity and shifting portions of the load from periods of maximum demand, can reduce costs and HVAC energy consumption, and is an effective way of reducing building energy consumption and improving the environment.

Keywords: phase change material; phase change wall; building energy saving.

With the rapid development of society economy and the standard of people's living continually improved, people put forward more comfort demand for living environment, so the cost of building energy consumption is increasing as well. In order to satisfy people's demands for comfort condition and so on to study and explore a building energy saving technology that will appropriate for our country. using reasonably and exploring stress a new reproducible energy resource has become our

country's a new focus in developing building energy saving of the town .Phase change storage energy technology just an important aspect of using in new powder resource and studying in energy saving .phase change storage material compound with solar power, electrical power and so on can provide an effective approach of increasing comfort in building as the same time reducing building energy assumption.

Phase change wallboard^[1 2] (PCW) is a kind of building encloses structure containing^[3 4 5] phase change material (PCM). They can be used in the small town. When indoor temperature is higher than phase change material in summer, PCM in the phase change wallboard will take place phase change, thaw, and absorb overhead in the room, make the air condition's cool load less than present building's. At night, we can make full use of relative clear environment in the town and are there we can obtain more nature cool resource compared with in the city. These cooling are used to dilution indoor heat, and then remove them from the room .So it can be enormously downsize air condition system and reduce first investment, operation, and serving expense of HAVC system .In winter, this kind of phase change wallboard by electricity at the peak-valley electric price differential compounded with heat set can absorb the heat in the night time that was produced by cheap electricity, while release the heat in the daytime .It not only can alleviate strained electricity load supplied , but also have higher economic benefit .

1. THE CHOOSE OF PHASE CHANGE

¹ Supported by Beijing Municipality Key Lab of Heating, Gas Supply, Ventilating and Air Conditioning Engineering (KF200614)

MATERIAL

Phase change material is enclosing structure in aspect of saving energy core content as operate media of wallboard storage energy system. We usually consider the phase change's thermal function, chemistry physical function and economy and so on when we choose the phase change material .PMC^[6] used in phase change wallboard must have bellow conditions (1) phase change temperature within indoor temperature (2) with higher latent heat(3) chemic cartelistic stability, not transpire, not metamorphose when cycling used for long time (4) consistent with building structure material(5) lower cost.

This experiment selected two kinds of fatty acid materials are PCM1 and PCM2. Both of them are compounded with different proportion 82 percentages and 18percentages by weight and obtained PCM3. After testing with DSC (Differential Scanning Calorimeter), we analyzed to know that phase change temperature of admixture PCM3 actives within indoor temperature zone, and have a higher latent heat.

2. PHASE CHANGE MATERIAL TESTING BY DSC METHOD

DSC is DSC7 series Thermal Analysis System of American PERDIN EIMER Company. fatty acid admixture PCM Used in testing is produced by a medicine(group) chemistry company of Shanghai in China. The weight of PCM sample is 10.607mg. In generally, DST testing considers 2 /min as heat or cooling velocity. This experimentation introduce a velocity which approach to indoor reality air temperature hoist or descend DSC introduce 0.2 /minscan velocity as ultimately experimentation testing. Fig1 is the DSC curve of admixture PCW3.

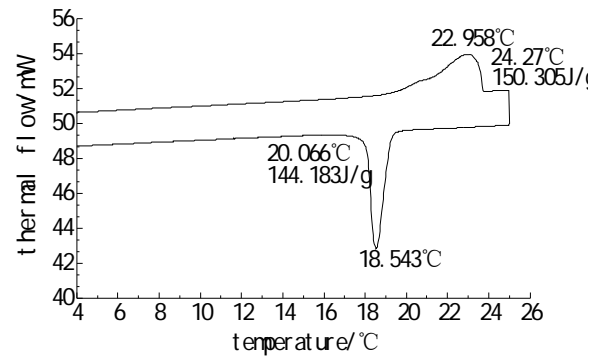


Fig.1 the DSC curve of PCW3.

From the fig1, we know that the melting point of the new fatty acid mixture PCW3 is 20.394 and the solidifying point is 19.138 , The peak of melting point is 22.958 and the peak of solidifying point is 18.543 .Melting latent is 150.305J/g and solidification heat is 144.183J/g .Therefore, the change temperature of PCW3 actives within indoor designed temperature, and has higher latent heat. It is a perfect phase change material and can be used with wallboard together.

3. THE PHASE CHANGE WALL

3.1 DSC testing on phase change wall

Wallboard's base materials are normal pasteboards used in fitment .Its thickness is 9.5mm and covered with paper on two surfaces .The method of PCW compounding with wall is direct dip .namely put plasterboard in a container where contains PCW3 , take it out from the container after 5 minutes ,and then arising up to keep a base constant weight .The wallboard after dipping with PCW can achieve the purpose of saving energy building consumption .this experimentation test used DSC method whose scan speed is 0.2 /min ,the weight of PCW sample is 12.424mg .Fig 2 show the curve of Phase change material PCW.

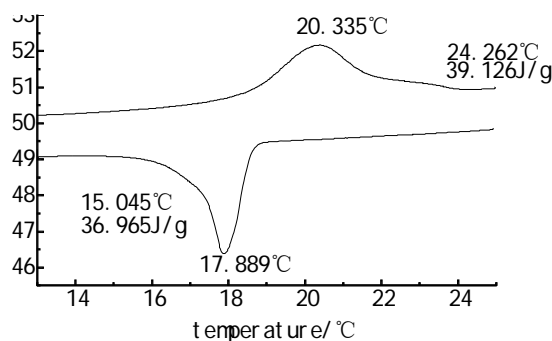


Fig.2 The DSC curve of PCM

3.2 Phase change wallboard compared with ordinary wallboard function.

This paper tested and compared phase change wallboard and ordinary wallboard about their specific heat, consistency and heat transfer coefficient and find special characteristic of phase change wallboard.

By the test of DSC, We can know that the specific heat of ordinary wallboard (plasterboard) and phase change wallboard. This paper carries on the comparison to the specific heat value obtained in the testing. Fig 3 show that the specific in phase change wallboard occurred to change process, which indicated that phase change wallboard have special storage capacity compared with ordinary wallboard.

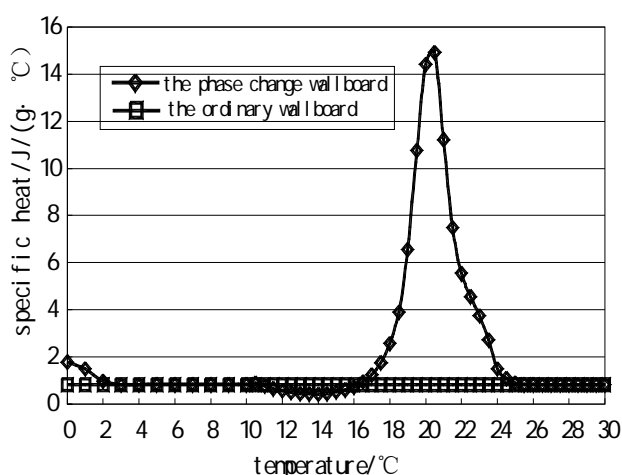


Fig.3 Specific heat curve of phase change wallboard and ordinary wallboard

From above DSC test result we can see that: according to the formula (1) in the phase change process, because absorbing or releasing of energy

change wallboard, in temperature going up process, enthalpy value with the difference in temperature variety is not line. But specific heat value of the ordinary wallboard doesn't with the absorption of the variety. The calories obtained in the process of temperature going up and difference in temperature keep basically the line relation. Fig 4 shows that curve of enthalpy and temperature going up process.

$$\Delta H = C_p \times \Delta T \dots (1)$$

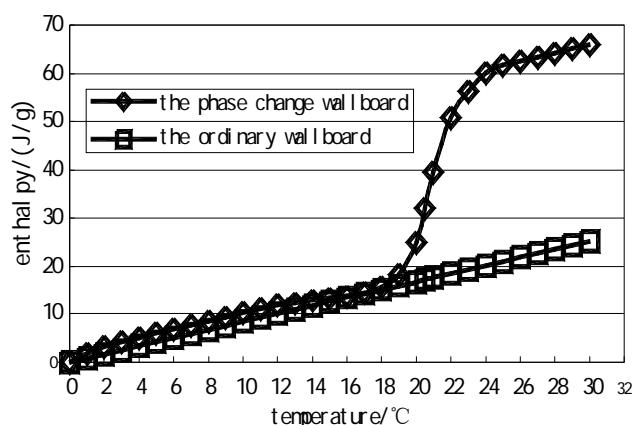


Fig.4 the Curve of temperature and enthalpy of phase change wallboard and ordinary wallboard

According to the parts of dates by the factory of plasterboard supplied and the experiment dates. We can get some others thermal performance of phase change wallboard and ordinary wallboard. See the table 1:

Tab.1 Thermal performance of the phase change wallboard and the ordinary wallboard

Wallboard	Consistency (kg/m ³)	Specific heat max(J/kg·°C)	Heat Transfer Coefficient (w/m ² ·°C)
Ordinary wallboard	750	840	0.173
Phase change wallboard	980—1050	1500	0.204

From the table, we can see that phase change wallboard have higher consistency, specific heat max and heat transfer coefficient than ordinary wallboard.

3.3 The enduring capability of phase change wallboard

In addition, the experiment tested on the enduring capability of finished phase change wallboard, namely carried on three hundred repetitions to the PCW samples. Operation process as follows: Put a phase change wallboard sample on the experiment test, experiment environment temperature is about 5 . Prepare a warm wind machine and a refrigeration box. the first period use warm wind machine to blow continuously the hot airflow to the phase change wallboard , After 20 minutes , the surface of phase change wallboard sample have been wet ,the color of the plasterboard become dark when we turn off the refrigeration box . Take it out from the container after 20 minutes and see the concrete phenomena. There is no trail of liquid around the phase change wallboard. Namely , finished one whole process of phase change repetition. Carry on three hundred times as that.

Overpass DSC testing, we record the dates of melting point and melting heat after repetitions and compared with the original dates. Fig 5 is the DSC curve of PCW after carrying on three hundred times cycling.

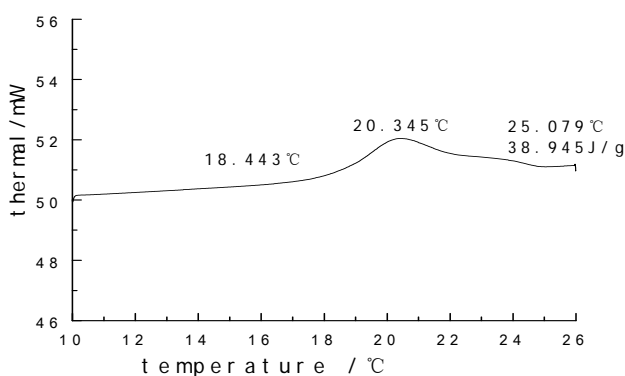


Fig.5 the DSC curve of PCW after carrying on three hundred times cycling

The DSC curve of PCW after cycling three hundred times Compare with the Fig 2, the phase change temperature of PCW and phase change latent heat keep basically the same after carrying on three hundred repetitions. Fig 2 shows the thermal Performance of PCW simple after carrying on three hundred cycling processes.

Tab.2 Melting point and melting heat of phase change wallboard sample before and after 300 cycling

Phase change cycling times	Melting point ()	Melting heat (J/g)
0	18.491	39.126
300	18.443	38.945

3.4 Applling of the phase change wallboard of northern country

The phase change wallboard as buildings enclose structure is used in the country of northern in China. When the temperature is higher than PCW's melting point in summer, the phase change wallboard will absorb overheat until indoor temperature is higher than the upper limit of melting the zone. In the night, we can make full use of nature cooling recourse to freeze PCM in the wall for releasing the heat that was absorbed in the daytime. This just finished phase change circulation. In winter ,by using nation drawing up the policy are the city residents were provided the same electrical price as the country's and reducing the electrical price in the country and foundation of at the peak-valley price differential ,make full use of the phase change wallboards and heat set together in the room ,use PCW to absorb indoor overheat which is provided by heat set in the night , while in the daytime the wallboard give the heat back to the room when indoor the temperature less than 18 , reduce the energy assumption of heat set and saving the electricity at the peak-valley electric price differential ,have a rather benefit . Otherwise, most of our country's laboratories locate suburb or village where the phase change material such as fatty and organic material can be produced expediently. Phase change material launch into using can strengthen the development of the country.

4. CONCLUSION

According to above expatiation, if the phase change wallboard are used in the northern country, we can take advantage of these superiorities are

lower electrical price and police of electricity at the peak-valley electric price differential and nature cooling resource in the night. Not only can reduce the cost and energy consumption of air condition system, but also is an effective way of improving building energy consumption to environment's negative effects. And in further study provide an approach of new energy resource regeneration for the areas of building energy and inaugurated some space for the development of building technology .It bring along the fast development of the small town economy. Therefore, the study not only has leaning value, but also can bring the obviously economic benefits. But the study of phase change wall of phase change materials in aspect of causticity, absorb water capacity and many others still need to be studied in further.

REFERENCES

- [1]zhang yan pin ,phase change energy storage—theory and applications [M].Beijing: science technology university of China publishing company, 1996.289-332
- [2]D Banu, D Feldman, D W Hawes. Evaluation of thermal storage as latent heat in phase change material wallboard by differential scanning calorimeter and large scale thermal testing. *Thermachimica Acta*,1998,317: 39-45.
- [3] Armin F Rudd. Phase-change material wallboard for distributed thermal storage in buildings. *ASHRAE Trans*,1993,99(2): 339-346.
- [4]Athienitis A.K.,Liu C.,Hawes D.,Banu D.and Feldman D.Investigation of the Thermal Performance of a Passive Solar Test-room with Wall Latent Heat Storage. *Building and Enviroment*,1999,32: 405-410.
- [5]zhangyanping ,kangyanbing. The study of phase change and chemistry reaction conversation in building HAVC, *HV&AC*,1999,29(5): 34-37.
- [6]S.D.SHARMA,D.BUDDHIandR.L.SAWHNEY.Ac celerated Thermal Cycle Test of Latent Heat-Storage Materials,*Solar Energy*,1999,66(6): 483-490.